Uranium
(U)

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Fact Sheet #27

Environmental Health Programs
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WHO DISCOVERED URANIUM?

Uranium was discovered by Martin Klaproth, a German chemist, in 1789 in the mineral pitchblende, and was named after the planet Uranus.

Some of the important isotopes of uranium are:

- U235 (half-life 703,800,000 years)
- U238 (half-life 4,468,000,000 years)

WHAT IS URANIUM USED FOR?

In the past, uranium was used to color glass (from as early as 79 AD) and deposits were once mined in order to obtain its decay product, radium. This element was used in luminous paint, particularly on the dials of watches and aircraft instruments, and in medicine for the treatment of disease. Uranium was popular as an orange coloring agent for ceramic glazes on Fiesta Ware until its use was restricted in 1943, and as an additive in porcelain teeth to improve their appearance.

Until the 1970s, virtually all of the uranium that was mined was used in the production of nuclear weapons. Today the only substantial use for uranium is as fuel in nuclear reactors, mostly in nuclear power plants for electricity generation. Uranium-235 is the only naturally occurring material which can sustain a fission chain reaction, releasing large amounts of energy.

Uranium Fuel

Natural uranium is composed of 0.72% U-235 (the fissionable isotope), 99.27% U-238, and a trace quantity 0.0055% U-234. The 0.72% U-235 is not sufficient to produce a self-sustaining critical chain reaction in U.S. style light-water reactors, although it is used in Canadian CANDU reactors. For light-water reactors, the fuel must be enriched to 2.5-3.5% U-235.

WHERE DOES URANIUM COME FROM AND WHERE IS IT FOUND?

Uranium was apparently formed by a super nova about 6.6 billion years ago. While it is not common in the solar system today, its radioactive decay provides the main source of heat in the earth's core causing convection and continental drift. As decay proceeds, the final product, lead, increases in relative abundance.

Uranium is slightly more abundant than tin and about 40 times as common as silver. It occurs in most rocks in concentrations of 2 to 4 parts per million and is as common in the earth's crust as tin, tungsten and molybdenum. It is also found in the oceans, at an average concentration of 1.3 parts per billion.

Because uranium occurs in soils and fertilizers, the element is present in food and human tissues. Most of the radioactivity associated with uranium in nature is in fact due to other minerals derived from it by radioactive decay processes, and which are left behind in mining and milling. The gamma radiation detected by exploration geologists looking for uranium actually comes from associated elements such as radium and bismuth, which over geological time have resulted from the radioactive decay of uranium.

Uranium is also found in the air due to suspended soil and coal fly ash. Uranium is found in varying degrees in the water.

There are a number of areas around the world where the concentration of uranium in the ground is sufficiently high that extraction of it for use as nuclear fuel is economically feasible. Such concentrations are called ore. When ore is mined, it yields a mixed uranium oxide product, (U_3O_8). This uranium oxide which, when purified, has a rich yellow color and is called "yellowcake". After reduction, the uranium must go through a uranium-235 enrichment process. Even with the necessity of enrichment, it still takes only about 3 kg of natural uranium to supply the energy needs of one American for a year.

IS URANIUM HAZARDOUS?

Uranium itself is radioactive, though with the major isotope U-238 having a half-life equal to the age of the earth, it has a low activity. U-235 has a half-life one sixth of this and emits gamma rays as well as alpha particles. A lump of pure uranium would give off some gamma rays, but less than from a lump of granite. It is a heavy metal, and, thus, is chemically toxic, being comparable to lead. Uranium metal is commonly handled with gloves as a sufficient precaution. Uranium concentrate is handled and contained so as to ensure that people do not inhale or ingest it.

Uranium enriched with U-235 is a concern for inhalation and ingestion, with the lungs and kidneys of principal concern. It is deposited in the mineralized bone volume of the skeleton.

WHAT IS DEPLETED URANIUM?

Depleted uranium is a by-product of the uranium enriching process by which the percentage of ^{235}U relative to ^{238}U is increased, or enriched. After removal of the enriched fraction the remainder contains about 99.8% ^{238}U, and 0.25% of ^{235}U by mass; this remainder is referred to as depleted uranium or DU.

Due to the high density of depleted uranium, it is used as ballast in commercial aircraft and yacht keels. Because of its high density and high atomic number, depleted uranium is sometimes used for shielding gamma radiation in medical radiation therapy machines and in containers for transporting radioactive materials, being some five times more effective than lead. Depleted uranium is also used in some pigments and glazes.

Due to its high density, about twice that of lead, and other properties, DU is used in munitions designed to penetrate armor plate and for protection of military vehicles such as tanks. DU is pyrophoric, so that upon impact about 30% of the projectile atomizes and burns to uranium oxide dust.

Individuals can be exposed to DU in the same way they are routinely exposed to natural uranium, i.e., through inhalation, ingestion, skin contact or injury (e.g., embedded fragments). The hazards associated with depleted uranium are the similar to those experienced with natural uranium. Due to the low activity, the radiation effects are not a major concern. The chemical toxicity of this heavy metal is similar to lead. Handling, inhalation and ingestion precautions should be taken.

PROPERTIES OF URANIUM-235 (^{235}U)

Half-Life:

Physical: 7.038×10^8 years

Sources:

Naturally occurring primordial nuclide, 0.720% of natural uranium, by mass, in the earth's crust. Enriched with respect to ^{238}U in fissionable material for reactors and weapons.

Principal Modes of Decay (MeV):

Alpha 4.22 (5.7%), 4.32 (4.4%), 4.40 (55%), 4.56 (4.2%), 4.37 (17%)

Gamma 0.196 (61%)

Special Chemical and Biological Characteristics:

When exposed to enriched uranium radiation, damage to the lung and kidney must be considered.

Principal Organs:

Mineralized Bone Volume

Amount of Element in Body:

90 µg with 59 µg fond in the skeleton

Daily Intake of Element in Food and Fluids:

1.9 µg

PROPERTIES OF URANIUM-238 (^{238}U)

Half-Life:

Physical: 4.468×10^9 years

Sources:

Naturally occurring primordial nuclide, 99.2745% by weight in natural uranium.

Principal Modes of Decay (MeV):

Alpha 4.21 (77%), 4.15 (23%)

Principal Organs:

Mineralized Bone Volume

Amount of Element in Body:

90 µg with 59 µg fond in the skeleton

Daily Intake of Element in Food and Fluids:

1.9 µg

Sources

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